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**AC 2008-2255: DECISION-MAKING IN FIRST-YEAR ENGINEERING:
EXPLORING HOW STUDENTS DECIDE ABOUT FUTURE STUDIES AND
CAREER PATHWAYS**

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Decision-Making in First-Year Engineering: Exploring How Students Decide about Future Studies and Career Pathways

Abstract

The number of students enrolling in engineering has declined steadily over the last fifteen years, and the number of engineers joining certain fields in engineering has decreased even more drastically. A number of studies have demonstrated a strong relationship between students' interests and abilities and their persistence in engineering. It is therefore logical to assume that students who choose a major which makes the best use of their skills and engages their interest, are more likely to not only stay, but also thrive in the field of engineering which they choose. Students who make a poor choice, because of incomplete information or misconceptions about various disciplines, often find themselves frustrated and sometimes leave engineering altogether.

A number of colleges offer first-year programs with the explicit intention of helping students make informed choices by introducing them to the various engineering disciplines before they are required to select one. The success of these programs depends on a better understanding of the processes and events that influence how students make decisions about their engineering major. The purpose of this study, conducted in a first year program, is to gain an understanding of the factors involved as students make choices about their careers in engineering. The study, conducted over a three year period, involved surveys, interviews, and narratives. This paper reports on a portion of the findings of that study. Initial results indicate that the reasons students choose to pursue a particular engineering discipline are very field specific.

Introduction

Incoming engineering students at a large public university enter the First-Year Engineering Program (FYEP) which is designed to be a year-long, common curriculum experience. All the First-Year Engineering Students (FYES) must successfully complete this program before entering the engineering professional school of their choice. There are over 1500 students entering the FYEP, and each of them must decide which of thirteen professional schools of engineering to enter. Approximately 13% of the FYES leave the FYEP before completing their first year. Knowledge of the reasons that motivate students' choice of the engineering profession and further the discipline of engineering they enter is important in order to successfully prepare students to make these choices.

In order to understand the landscape of the current research around this topic, a review of the literature was carried out. A number of studies indicated a relationship between students' interests and performance and their persistence in engineering. For example, a study conducted at one university with a phenomenographical focus found that enjoyment, interest, and satisfaction were major factors associated with students' success in engineering¹. It is therefore reasonable to assume that students who choose a major which maximizes their interests and performance are more likely to stay in engineering.

The personal, academic, behavioral and environmental factors which influence a person's career choice and performance have been explained using the Social Cognitive Career Theory

framework^{2,3} (SCCT) in a number of studies. This theory asserts that people choose their career based on their perceptions of their strengths and their expectations of the results of those choices^{2,3}. These perceptions of themselves and of the results of their choices are strongly influenced by social constructions such as those about gender and race⁴. SCCT and other theories have provided a framework for a number of studies that sought to determine why students choose to pursue engineering as a career. These reasons include their belief that engineering makes the best use of their talents and abilities^{5,6,7,8}, job security, social status, prestige, high income, family influence⁸, teacher influence, rewarding career opportunities, access to information on career opportunities⁹, high scores on aptitude tests, influence of friends and mentors⁷, opportunity to serve community, open up future options for study⁵ etc. However, little work has been done to explain why particular fields of engineering are chosen. While we seem to understand some of the cognitive processes that underlie decision-making and the factors which influence students' to pursue a career in engineering, understanding of the way in which, or the reasons why students choose one engineering discipline over another is rather limited.

While not much theoretical work has been done in this area, various colleges and universities have recognized the importance of helping students make the best choices about their engineering careers. Programs, such as the EPICS program at one university, allow students to gain a better understanding of various disciplines by participating in engineering projects in the community¹⁰. Colleges and universities also use introduction to engineering or first year seminar courses in engineering to introduce students to the different fields in engineering by having projects and labs relating to different disciplines, or having guest speakers come in to give introductions to the different disciplines^{5,11}. Other colleges allow students to take several introductory courses in various areas to allow them to explore and gather information on various fields¹².

A study of one such introductory program found that approximately 30% of students choose their engineering discipline before enrolling in college, the rest make their decision as they go through their first year and beyond¹³. High school teachers and counselors, extracurricular activities, family members, faculty members, and peers were identified as some of the factors influencing their decision. Having systematic programs to assist students has also been shown to have an effect on students' decision-making as regards choosing an engineering field; programmatic factors and self-exploration were found to be the largest influences on students' decision-making process¹³. It is not clear however, exactly what these influences comprise of and how they affect the decision-making process. This study sheds some light on these factors by asking students what their first and last choices of discipline were and why these were their top and bottom choices.

Methods

This study was carried out over a period of three academic years from the fall of 2005 to the spring of 2008. This period encompasses three incoming classes of FYES. Participants in the study were incoming FYES recruited from the FYEP. In the initial year of the study six groups of 6-9 students participated in a series of focus groups. These students were randomly selected and recruited by email. In the second year of the study participants were again recruited from the incoming class of FYES. Four students participated in a final focus group while another twelve

students participated in individual in-depth interviews. These students were recruited by two means: from the introductory engineering problem solving class, and by means of the academic advisors. Participants in the third year of the study were recruited from that incoming class of FYES. 974 students responded to an online survey. Subjects were recruited from the first-year engineering lectures class. This paper reports on a small portion of the findings from the survey administered in the third year of the study.

The survey was administered electronically to 974 FYES. It was separated into four sections; the first of these was designed to elicit background information, the second section was made up of open-ended questions designed to draw out information about the main elements and processes influencing the choice of a particular discipline or that to leave engineering altogether, the third section was a questionnaire designed to discover one's orientation on a person/thing scale, and the fourth section outlined opportunities for further participation in the study and invited respondents to participate further. Partial results from the analysis of four questions from the second portion of the survey are presented below.

This study used qualitative research methods to understand the participants' explanations of their choices. An inductive methodology was used whereby the data were analyzed for emerging patterns and themes. This was done iteratively by identifying core factors from students' responses, and using these factors to further classify the students' responses. Further work with these data will include independent analysis by several researchers, after which results will be compared, and triangulation with a combination of various data sources, i.e. interviews, survey data, and narratives will be used to ensure the reliability of the results.

Results and Discussion

Of the 974 participants in the study, 814 were male, 153 were female, and 7 did not indicate their gender. The racial distribution of the study is displayed in Figure 1 below. 88% of the respondents had college graduates in their family and 57% had engineers in their family. 70% of those responding to the survey had already chosen an engineering professional school (the survey was taken at the conclusion of their first semester midway through the FYEP).

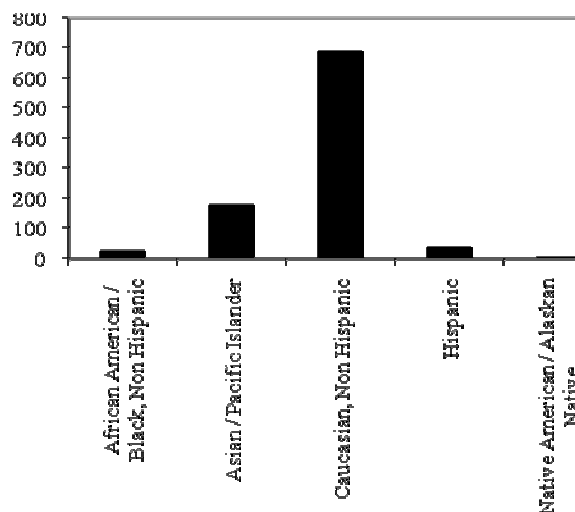


Figure 1: Racial distribution of survey respondents

The participants in the study were asked to indicate which professional schools they would choose as their first and last choice if they were required to make a choice immediately. They were also asked to explain the reasons for their choice. Participants were asked to name their first as well as their last choice in order to elicit both the factors that attract them to a discipline and those that repel them. This allows us to get a more complete picture of the factors influencing their choices, and how those factors come into play. The most frequent choice in this sample by far was Mechanical Engineering picked by almost 24% of the sample. Following this were Electrical and Computer Engineering (15.1%), Civil Engineering (14.4%), and Aeronautics and Astronautics (13.9%). The discipline chosen most frequently as the participants' last choice of professional school was Chemical Engineering selected by 21.3% of respondents, followed by Biomedical Engineering (12.6%), Agricultural and Biological Engineering (11.8%), and Nuclear Engineering (10.9%). Figure 2 represents the first and last choices across the thirteen professional schools.

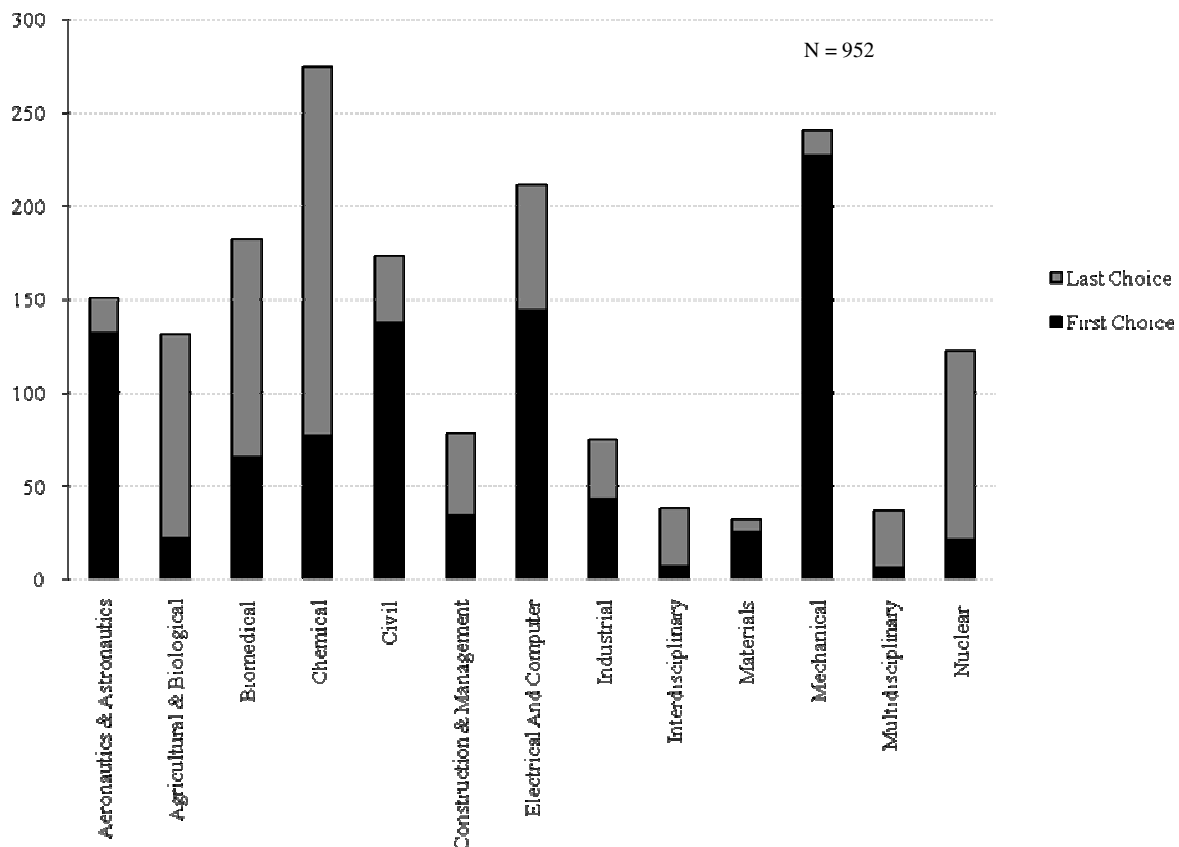


Figure 2: Distribution of first and last choice of professional school

Four of these disciplines, (Aeronautics and Astronautics, Civil Engineering, Industrial Engineering, and Mechanical Engineering), were chosen and a further analysis was carried out on them. Mechanical Engineering was selected because it was the most commonly chosen

discipline, Civil Engineering and Aeronautics and Astronautics were chosen to represent the middle of the spectrum, (Civil because it is fairly typical of engineering schools across the country and Aeronautics because it seemed more particular to this university), and Industrial Engineering to represent the low end of the spectrum. (Future publications will include the results of the analysis of other disciplines).

Aeronautics and Astronautics was well represented amongst this sample with 13.9% of the students picking it as their first choice. The most common reason students gave for choosing this discipline was that they loved to fly (Table 1). Other common reasons given were: interest in space, interest in designing and building planes, interest in working with their hands, love of math and physics, and interest in problem solving.

Table 1: Sample quotes from students who chose Aeronautics and Astronautics as their first choice

Reasons for interest in discipline	Sample quotes from students
Enjoy flying	<p>“I am a pilot and have great interest in aviation”</p> <p>“I enjoy flying, and I have build model planes before. Doing that on a life-size scale would be fun.”</p> <p>“I have been interested in flying since I can remember and have figured an aeronautical engineering degree would fit nicely with a pilot's license in the job world. I would then have the practical background to not only fly and airplane but still be able to design them also. This is really just the job description of a test pilot or astronaut.”</p>
Interested in space	<p>“I have always been interested in space and space technology.”</p> <p>“I have high interest in knowing about space which makes aerospace a good fit for me.”</p> <p>“I enjoy space and space exploration, as well as flight and the concepts involved.”</p>
Love math and physics	<p>“I love math and physics. Being able to apply these in real life would give me my dream job. Plus, I want to become an astronaut eventually and work experience in designing air/spacecraft would probably get me a foot in the door.”</p> <p>“Aerospace engineering is perfect for me, because it involves lots of physics and complicated math. Those are my two strongest subjects that I love. I am also fascinated with flight and anything to do with space. I love watching the science channel to learn about the man wonders of our universe and the endless line of mysteries we have yet to uncover.”</p> <p>“This professional school would be a good fit for me because of my passions for math, physics, and the advancement of humankind into outer space.”</p>

Students who indicated that Aeronautics and Astronautics was their first choice overwhelmingly chose Chemical Engineering as their last choice (Figure 3). Other less frequently selected disciplines, in this sample, included Agricultural and Biological Engineering and Biomedical Engineering. The major reasons given for these choices were a dislike, or lack of aptitude for chemistry, a disinterest in farming, and a lack of interest in the medical field.

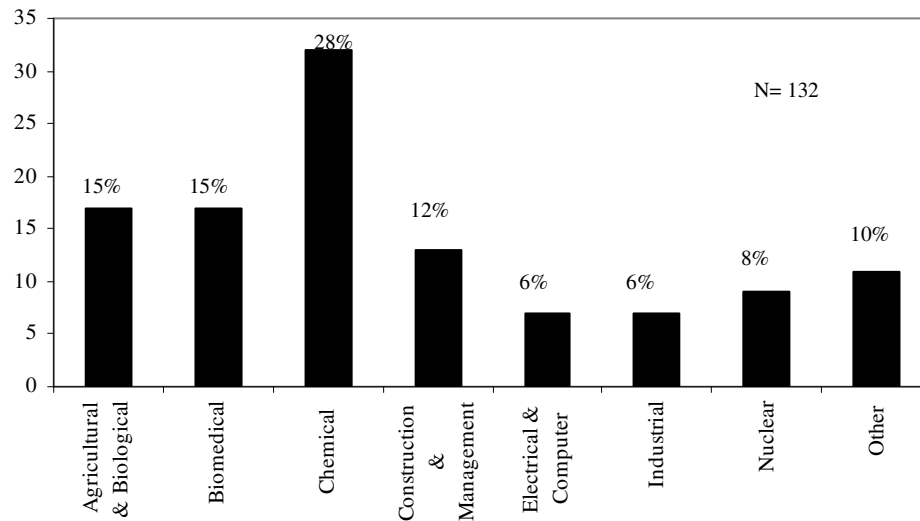


Figure 3: Distribution of last choice of professional school chosen by FYES who chose Aeronautics and Astronautics as their first choice

Civil Engineering was also well represented in this sample with 14.4% of participants choosing it as their first choice of professional school. The most common reasons for this choice were that this discipline gave them the opportunity to work outdoors and the chance to work with their hands building things. Other reasons included an enjoyment of structural design, being able to immediately see the fruits of your labor, previous positive experience with construction work, and the attraction of building something with longevity. Sample quotes from these respondents are displayed in Table 2.

Table 2: Sample quotes from students who chose Civil Engineering as their first choice

Reasons for interest in discipline	Sample quotes from students
Opportunity to work outdoors	<p>"Hands on is the number one reason I chose both of these. I don't mean just research hands on, I mean going out into the field and actually looking at stuff. I don't want to be inside all day; I want to see the thing being built."</p> <p>"I like to work outdoors and civil engineers get to go out to the sites"</p> <p>"I think that being a civil engineer would allow me to work outside from time to time and get out of the cubical."</p>
Opportunity to work with hands	<p>"I like working with my hands and in teams."</p> <p>"I like building things and working with my hands and I love being around other people working with them"</p> <p>"I am very good with hands on work. Since I was little I have been building and taking this apart. I have had a chance to work with concrete and steel at a program at M School Of Engineering."</p>
Longevity of results	<p>"Civil engineering makes me think not just the practical aspects of a problem, but also the longevity of its solution. This is appealing to me"</p> <p>"I would really like the idea of designing something I could see every time I passed."</p>

Students who chose Civil Engineering as their first choice most commonly chose Chemical Engineering as their last choice closely followed by Nuclear Engineering (Figure 4). The major reasons for these choices were a dislike or perceived lack of aptitude for Chemical Engineering, a dislike of working with chemicals, a disinterest in working indoors, and a fear of radioactive materials.

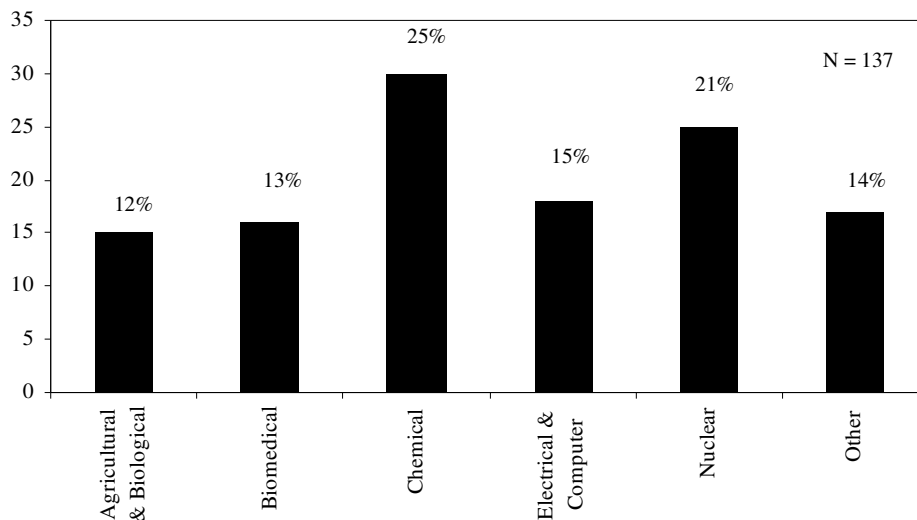


Figure 4: Distribution of last choice of professional school chosen by FYES who chose Civil Engineering as their first choice

Industrial Engineering was not particularly well represented in this group with only 4.5% of the sample choosing it as their first choice of professional school. The main reason students picked this discipline as their first choice was that they saw it as a convenient way into engineering management, and as a chance to use more business than technical engineering skills. Other reasons students were attracted to Industrial Engineering were that: they were interested in efficiency, it allowed them to work with people, and they had an opportunity to study and eventually practice in a wider range of areas. Table 3 displays samples of quotes from these respondents.

Table 3: Sample quotes from students who chose Industrial Engineering as their first choice

Reasons for interest in discipline	Sample quotes from student
Way into engineering management	<p>"I chose Industrial since it is a lot like business. Every major CEO is an industrial engineer now, and the new people my dad hires for his company are, so I need to be one to stay on top of things."</p> <p>"I think Industrial engineering is less technical and more business-like."</p> <p>"Every company I have worked for, I have run into poor management. I want to be an industrial engineer and get into a management position because I believe that I would excel in a management position."</p>
Interested in efficiency	<p>"I have always seen the world in a logical manner, and as such I successfully solve problems quickly and efficiently. As for industrial engineering, I have always been interested in profit and efficiency, so industrial engineering seems the best fit for my sort of mindset."</p>

	<p>“I would be interested in industrial engineering because I believe it is very important in society today to have systems that work efficiently. It also interests me more than the other fields due to its broad range of application and broad job market. It also is very business like because it deals with not only managing equipment systems but also human systems and how to make the human workers have maximum efficiency.”</p>
Interested in people	<p>“I’m interested in Industrial Engineering because they work with lots of different people, not just the same people all the time.”</p> <p>“Industrial engineering relates with how people live and interact with industry.”</p>

Students who chose Industrial Engineering as their first choice most commonly chose Nuclear Engineering as their last choice closely followed by Chemical Engineering and Biomedical Engineering (Figure 5). The major reasons for these choices were a dislike or perceived lack of aptitude in chemistry, a lack of interest in working with radioactive materials, and a perception that these fields were boring and repetitive.

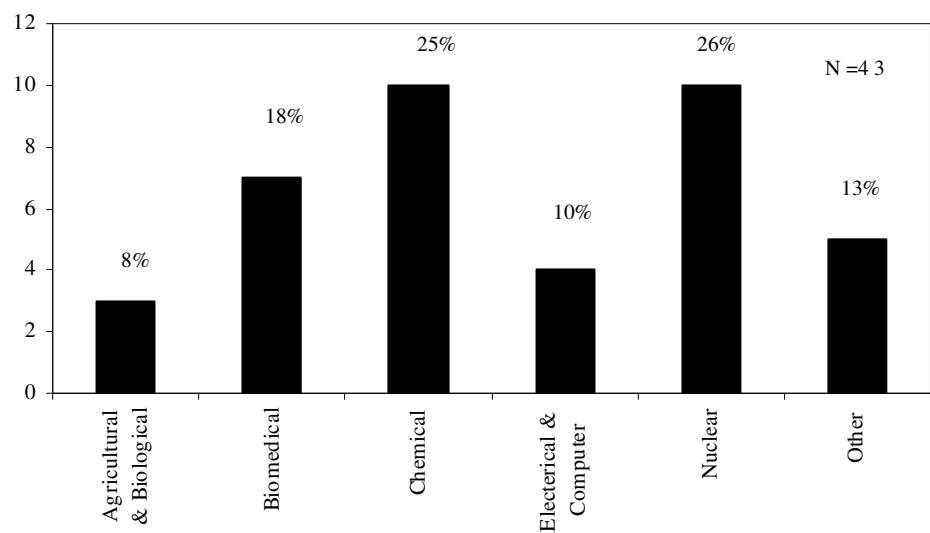


Figure 5: Distribution of last choice of professional school chosen by FYES who chose Industrial Engineering as their first choice

In this sample, Mechanical Engineering was the most frequently chosen school with almost 24% of the sample choosing it as their first choice. The most common reason students gave was that they liked to work with mechanical things, or perceived themselves as mechanically inclined. Other reasons for the attraction to Mechanical Engineering included a love of physics, the opportunity to work with their hands, the opportunity to be creative, the flexibility of the field, and the potential to solve problems.

Table 4: Sample quotes from students who chose Mechanical Engineering as their first choice

Reasons for interest in discipline	Sample quotes from students

Mechanically inclined	<p>"I am a very mechanically inclined person. I can take apart an engine, clean it, and rebuild it."</p> <p>"I think very thoroughly and enjoy puzzles. My Eagle Scout project most likely started my civil engineering craze; I spent 600 personal hours designing a paver platform in front of a park district building. I enjoy these types of things, and don't see myself doing much else. I love music and acoustical engineering could be fun too."</p> <p>"As a child, I've always enjoyed constructing rudimentary machines out of legoes and k-nex. I feel like I have a slight mechanical inclination due to the exposure I've already had. Industrial engineering is not necessarily something I maybe good at, but would enjoy doing."</p>
Opportunity to work with hands	<p>"I love to design and create things with my hands."</p> <p>"I enjoy problem solving and using my hands. This field also allows me to works with my hands more than others."</p>
Career flexibility	<p>"The wide variety of job opportunities after college."</p> <p>"ME graduates can become lawyers or consultants. Both of these careers interest me."</p> <p>"The characteristics of this school that really interests me and makes me think that it is a good choice for me are the following reasons. ME is a very broad, and open profession, and I would not be limited to what I could do after graduating."</p>

Students who chose Mechanical Engineering as their first choice overwhelmingly chose Chemical Engineering as their last choice followed by Biological Engineering (Figure 6). The main reasons that were reported for this were a lack of interest, or perceived lack of aptitude for chemistry, a disinterest in the medical field, a dislike of biology and farming, and a desire not to work with people.

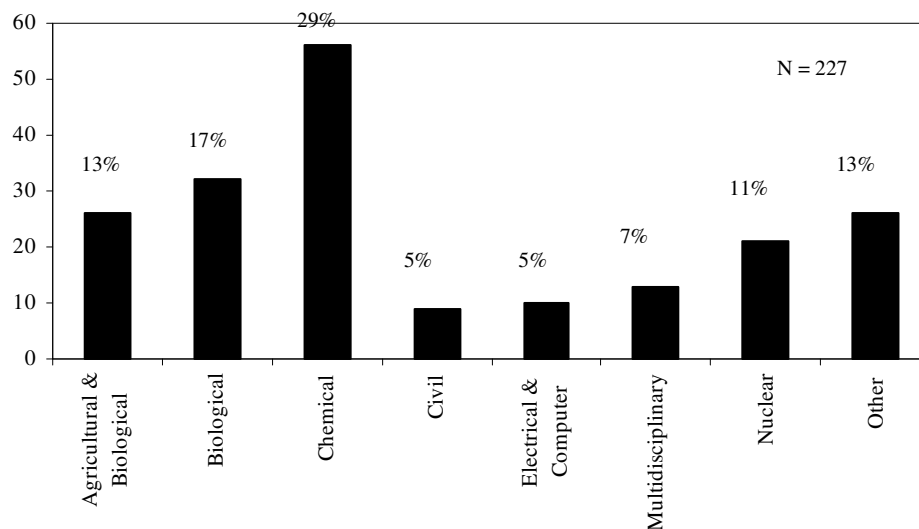


Figure 6: Distribution of last choice of professional school chosen by FYES who chose Mechanical Engineering as their first choice

Several patterns emerge from the results above. It appears that in this sample and based on the current state of our analysis that certain fields, for example Chemical Engineering, might be selected less frequently based on a widespread belief amongst students that chemistry is difficult and uninteresting. Furthermore, fields represented by Agricultural and Biological Engineering,

Nuclear engineering and Biomedical Engineering might be selected less frequently not on a basis of perceived difficulty or easiness of subject. In certain cases, disinterest was justified based on perceived qualities of the unique subject of study such as the human body or farming. Fear of radioactive material appears to be a common perception for lack of interest in Nuclear and Chemical Engineering.

Another interesting pattern that emerged is that students saw all fields as providing the opportunity to exercise problem solving skills. That students from all fields identified this as an attraction implies that it is a central characteristic/attraction of engineering generally in students' minds. An additional interesting pattern seen here is that contrary to the commonly accepted opinion of engineers as socially awkward and uninterested in people, a major attraction in many engineering fields is the opportunity to work with others.

Conclusion

The purpose of this study was to explore and understand the processes by which FYES make decisions about the direction of their future studies and career pathways in engineering. This paper presents a small portion of the findings from this study. These results indicate that in this sample and with the current state of analysis, Mechanical Engineering, Electrical and Computer Engineering, Civil Engineering and Aeronautics and Astronautics are the most frequently selected disciplines. On the other hand, students have a dislike and fear of chemistry which discourages them from Chemical Engineering. Students also displayed disinclination towards Biomedical and Agricultural and Biological Engineering based not on a corresponding dislike of biology, but rather on a disinterest in the associated professional fields i.e. medicine and farming. These results also indicate that FYES in many cases have more of an interest in working with people than things, and that they are interested in a wide range of subjects outside of those traditionally considered engineering subjects. In addition, it is clear that students often hold stereotypical perceptions of engineering disciplines and that more can be done to show them the true depth and diversity of many engineering fields.

Note about Future Work

This paper presents an initial look into this area of study, while an ongoing analysis is in progress. While understanding the reasons why students make professional selections is extremely important, the complexity of how these decisions are shaped by various factors including race, gender, access to opportunity, peers, and family is also of great interest. Deeper analysis will include a more in-depth look at how these factors affect decision-making, and the process by which these decisions are made. Further research will also examine the effects of these decisions and decision-making processes on students' success and retention in their fields.

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